

HAEMATOLOGY OF THE CAMELIDAE

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Aside from the common misinformation that the red cell of the camel is oval and nucleated, there is surprisingly little known concerning the haematology of the Camelidae. Gulliver (1875) gives the diameter of their dried red cells. Bottcher (1877) describes the erythrocytes as being nucleated. Ponder (1924) lists red cell counts and measurements for various species, and also points out that there is no evidence for Bottcher's statement that the camel red cells are nucleated. Concerning the white cells there is no reliable information available.

The purpose of this study is to give concisely and yet with sufficient detail the haematology of the Camelidae (which includes the camels and "cameloids"). In all cases the blood was taken into oxalate from a neck vein of healthy animals kept under the ordinary conditions of captivity. The examination of the cells was commenced within one hour from the time of withdrawing the blood.

Unless otherwise stated, the following descriptions and differential counts are based on blood films prepared by the smear method stained with Wright's blood-stain. The red cell counts were made in the usual way, using Hayem's solution. Triplicate counts were made and the average result per cubic millimetre is given. The white cell counts were obtained in a similar way, using a solution of acetic acid for dilution. The haemoglobin was estimated as carboxy-haemoglobin by Palmer's colorimetric method, with the blood of one of us (H. A. C.) as a standard (100 per cent). These readings were made in triplicate and the average determined. The polynuclear counts were made in the manner described by Cooke (1914), and on 100 cells. The stain employed was iron haematoxylin, but counts can also be made on films stained with Wright's or Giemsa's stain. The method used for determining the resistance

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of the red cells to haemolysins has been adequately described by Ponder (1927) and Yeager (1928), while the technique for studying the dimensions of the red cells has also been given in full by Ponder and Millar (1924).

I. *Llama glama*

a—The red cells, when seen in the fresh state in plasma, have the appearance of flattened ellipsoids, with a perfectly regular outline and homogeneous structure. The erythrocytes do not form typical rouleaux, but remain in contact with one another so as to form 'chains,' one end of one cell overlapping the end of the cell next to it, and so on.

In stained films the red cells appear smaller than in the fresh state, but retain their shape remarkably well. Measurements of the length and breadth of these cells in the fresh and dried preparations show a definite change in size on drying.

Fresh red cells in plasma—Length 7.8 μ . Breadth 4.3 μ .

Red cells in dried films—Length 7.2 μ . Breadth 3.9 μ .

When the erythrocytes are fixed in methyl alcohol, the haemoglobin is especially deposited in the central parts of the cell, and as a result the central area takes on a deeper stain than the peripheral region. This appearance may possibly be responsible for the erroneous statement which has sometimes been made that the cells are nucleated.

b—The average haemoglobin percentage is 89 per cent.

c—Red cell count (cells per cubic millimetre)—11,300,000.

d—White cell count (cells per cubic millimetre)—10,300.

e—The morphology of the white cells of a young specimen shows no outstanding difference as compared to that of the adult. It may be noted, however, that the blood of young animal stains more rapidly and gives a better differentiation than that of the adult.

1—The polymorphonuclear neutrophilic leucocytes (P. M. N.) are approximately circular and range in size from 10 to 12 μ . The nucleus is quite irregular in form, showing the familiar lobations of polymorphs in general. The cytoplasm is slightly acidophilic in reaction and studded with many fine granules which are neutrophilic and which stain a lilac color in some cells and pink in others.

2—The polymorphonuclear eosinophiles (P. M. E.) are circular or slightly oval in shape and fairly constant in size, 10 μ . Their nucleus is similar to that of the neutrophile just described, but stains less intensely. The cytoplasm, which stains a very light blue and is hardly distinguishable, is practically filled with coarse bright red granules.

3—The polymorphonuclear basophilic leucocytes (P. M. B.) are fairly circular in outline, and are the smallest of the polymorphonuclear leucocytes, 8 μ . The nucleus which occupies the greater part of the cell is difficult to differentiate since it is basophilic in staining quality and takes a blue-purple color slightly less intense than that of the coarse granules which fill the cytoplasm.

4—The lymphocytes (L.) are more circular than any of the other blood elements and range in size from 8 to 10 μ . The nucleus is circular or slightly ovoid in outline, stains a deep blue, and fairly fills the cell, leaving a variable margin of faint sky-blue tinted cytoplasm. Occasionally a few scattered azure granules of variable size may be seen.

5—The large mononuclear leukocytes (L. M.) are variable in outline from perfect circles to irregular ovals. They average approximately 12 μ in size. The eccentrically-placed nucleus stains deep blue, yet several shades lighter than that of the lymphocytes, and presents a slight indentation on the side toward the larger area of cytoplasm. The cytoplasm which stains a light blue similar to that of the lymphocytes invariably contains a goodly number of coarse, azure granules.

6—The transitional leukocytes (T.) are large ovoid cells ranging from 10 to 12 μ in size. The nucleus appears eccentrically placed and deeply notched, and stains similar to that of the polymorphocuclear leukocyte. The cytoplasm stains a light blue and contains a large number of neutrophilic granules which tend to be concentrated and more deeply stained in the notch of the nucleus. It is difficult to distinguish these cells from the Class I polynuclear neutrophilic leukocytes.

f—The differential count as determined by classifying the cells according to the description just given is:

P. M. N.	63	L.	11
P. M. E.	10	L. M.	4
P. M. B.	10	T.	2

g—The polynuclear count for this animal is very much the same as in man and rabbit.

	I	II	III	IV	V
<i>L. glama</i>	14	29	40	13	4

h—Resistance of red cells to haemolysins.

1—The resistance to saponin was found to be 0.75 times as great as in man.

2—The resistance to sodium taurocholate is 1.20 times as great as in man.

3—The red cells were found to be resistant to 0.28 per cent saline which is a decidedly greater resistance than is shown by human erythrocytes which haemolyze at 0.32 per cent saline.

II. *Llama pucas*

a—The general morphology of the red cells of *Llama pucas* is essentially the same as that of *Llama glama*. The measurements are slightly different, and are given merely as a matter of record.

Fresh red cells in plasma—Length 8.0 μ . Breadth 4.3 μ .

Red cells in dried film—Length 7.6 μ . Breadth 4.1 μ .

b—Haemoglobin, 106 per cent.

c—Red cell count, 19,400,000.

d—White cell count, 12,100.

e—The general morphology of the blood elements are so much alike that for the sake of brevity the description given for *Llama glama* is adequate for

Llama pomas. The following brief note on each type of cell will therefore be limited to those differences deemed of note.

1—The polymorphonuclear neutrophilic leukocytes (P. M. N.) vary in size from 8 to 10 μ . The neutrophilic granules are regularly placed and somewhat coarser than ordinarily. Both the granules and cytoplasm stain poorly and in a large number of cells are decidedly chromophobic.

2—The polymorphonuclear eosinophilic leukocytes (P. M. E.) are approximately 8 to 9 μ in diameter, irregularly oval in outline and heavily studded with large bright red granules.

3—The polymorphonuclear basophilic leukocytes (P. M. B.) are surprisingly frequent in occurrence. They are approximately circular in outline and 4 to 5 μ in diameter. It is impossible to differentiate the nucleus which is practically lost in the heavy deeply staining basophilic granules which fill the cytoplasm.

4—The lymphocytes (L.) are definitely circular in outline and 6 to 8 μ in diameter. The nucleus is centrally located, leaving a narrow border of clear blue cytoplasm. No azure granules were observed.

5—The large mononuclear leukocytes (L. M.) average 10 μ in diameter. The eccentrically placed, notched nucleus stains the same as that of the lymphocytes.

6—The transitional leukocytes (T.) range from 10 to 12 μ in size. The neutrophilic granules of the cytoplasm, as well as the cytoplasm itself, stains well, and therefore can be used as a differential for distinguishing between this type of cell and a Class I polynuclear neutrophilic leukocyte.

f—Differential Count:—

P. M. N.	51	L.	4
P. M. E.	5	L. M.	2
P. M. B.	37	T.	1

g—Polynuclear Count:—

	I	II	III	IV	V
<i>Llama pomas</i>	22	31	37	8	2

h—Resistance to haemolysins:—

1—The resistance to saponin was found to be 1.00 times as great as in man.

2—The resistance to sodium taurocholate is 1.90 times as great as in man.

3—The red cells were found to be resistant to 0.28 per cent saline which is a decidedly greater resistance than is shown by human erythrocytes which just haemolyze at 0.32 per cent saline.

III. *Camelus dromedarius*

a—With the exception of the slight difference in size the red cells of this animal are very similar to those of *L. glama* and need no further description.

Red cells sizes:—

Fresh red cells in plasma—Length 8.0 μ . Breadth 4.6 μ .

Red cells in dried film—Length 7.1 μ . Breadth 4.1 μ .

b—Haemoglobin, 96 per cent.

c—Red cell count, 10,800,000 per c. mm.

d—White cell count, 12,000 per c. mm.

e—With the exception of the differences in size the cells of this animal are so similar to those of *Llama glama* that the morphological description given in part one can be applied to the various cellular elements of this blood.

1—The polymorphonuclear neutrophilic leukocytes (P. M. N.) are fairly constant in size, 13 μ .

2—The polymorphonuclear eosinophilic leukocytes (P. M. E.) are comparatively numerous. The coarse granules which fill the cytoplasm stain a deep pink rather than the characteristic bright red, and the cell shows an irregular ragged outline. Their size is roughly 11 μ .

3—The polymorphonuclear basophilic leukocytes (P. M. B.) are 10 μ in diameter. The coarse granules which fill the cytoplasm seem to stain more intensely at the periphery of the cytoplasm where they appear almost blue black in contrast to the definite deep purple of the other granules closer to the nucleus.

4—The lymphocytes, (L.) which are approximately 8 μ in diameter, have a very thin cytoplasmic rim which stains the usual sky-blue. In some cases the deep blue nucleus appears to fill the cell completely and no cytoplasmic rim can be differentiated.

5—The large mononuclear leukocytes (L. M.) average about 13 μ in size and show light blue staining granules in the cytoplasm rather than the azure granules as usually described.

6—The transitional leukocytes (T.) are easily recognized because of their size, 15 μ . The eccentrically placed indented nucleus, however, is not proportionately as large and as a result there is a good deal of cytoplasm to be seen. The fine neutrophilic granules are sparsely scattered throughout the cell.

f—Differential Count:—

P. M. N.	55	L.	8
P. M. E.	27	L. M.	6
P. M. B.	3	T.	1

g—Polynuclear Count:—

	I	II	III	IV	V
<i>C. dromedarius</i>	24	35	32	7	2

h—Resistance to haemolysins:—

1—The resistance to saponin was found to be 1.03 times as great as in man.

2—The resistance to sodium taurocholate is 1.72 times as great as in man.

3—The red cells were found to be resistant to 0.28 per cent saline which is a decidedly greater resistance than is shown by human erythrocytes which just haemolyze at 0.32 per cent. saline.

IV. *Camelus batriens*

a—The red cells of this species are sufficiently similar to those of *L. glama* as to warrant no descriptions other than a notation of their sizes.

Fresh red cells in plasma—Length 8.1 μ . Breadth 4.5 μ .

Red cells in dried film—Length 7.5 μ . Breadth 3.6 μ .

b—Haemoglobin, 87 per cent.

c—Red cell count, 10,450,000.

d—White cell count, 10,800.

e—There is no marked difference in the staining quality or morphology of the blood elements of the young animal as compared to that of the adult. The leukocytes of this species of camel are larger and better differentiated than those of the other species studied in this group.

1—The polymorphonuclear neutrophilic leukocytes (P. M. N.) are irregular in outline tending more toward the circular than the oval in shape. Their approximate mean diameter is fairly constant, measuring approximately 16 μ . The nucleus which is typically polymorphous stains a light reddish purple. The cytoplasm which is clear and very slightly tinted a light blue contains various sized evenly stained neutrophilic granules.

2—The polymorphonuclear eosinophilic leukocytes (P. M. E.) are typical. They measure approximately 12 to 14 μ in diameter.

3—The polymorphonuclear basophilic leukocytes (P. M. B.) are circular in outline with an irregular incompletely lobed nucleus which stains a reddish purple, making it easily distinguishable from the light blue cytoplasm thickly packed with coarse deep blue or purple stained granules. These cells measure about 8 to 10 μ .

4—The lymphocytes (L.) vary in size from 12 to 16 μ and contain a large deep blue staining nucleus which is slightly eccentric in position. The irregular rim of cytoplasm stains the typical sky-blue.

5—The large mononuclear leukocytes (L. M.) are irregularly circular in outline. The nucleus which is large and deeply indented stains a reddish purple. The sky-blue cytoplasm contains many azure granules clumped, as usual, in the indentation of the nucleus. These cells are rather constant in size, measuring about 22 μ .

6—The transitional leukocytes (T.) contain a deep blue staining nucleus in a pink colored cytoplasm which is filled with typical neutrophilic granules. These cells are very large, averaging approximately 30 μ in diameter.

f—Differential Count:—

<i>Adult</i>	P. M. N.	67	L.	11
	P. M. E.	15	L. M.	3
	P. M. B.	2	T.	2

g—Polynuclear Count:—

	I	II	III	IV	V
<i>C. batriens</i>	23	36	34	6	1

h—Resistance to haemolysins:—

1—The resistance to saponin was found to be 0.96 times as great as in man.

2—The resistance to sodium taurocholate is 1.42 times as great as in man.

3—The red cells were found to be resistant to 0.26 per cent NaCl, which

is a decidedly greater resistance than is shown by human erythrocytes which haemolyze at 0.32 per cent saline.

It cannot be expected, of course, that the examination of the necessarily few specimens of each species will provide us with perfectly trustworthy information, for allowance has to be made for individual variations; we believe, however, that the data presented is both more representative and more trustworthy than any at present existing.

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(A fuller account of these investigations will be found in the following paper:—
Studies in Comparative Haematology. I. Camelidae. Quarterly Journal of Experimental Physiology, vol. xix.)